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Jockey Club College of Veterinary Medicine and Life Sciences
香港城市大學
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JCC RESEARCH SEMINAR

TOPIC

Biophysically Detailed Brain Simulations: Future Stars in Brain Science and AI?

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ABSTRACT

The recent success of the Super AI model, "ChatGPT," is transforming our understanding of intelligence. One captivating notion is that ChatGPT's intelligence seems to automatically "emerge" from an immense and intricate artificial neural network with 170 billion parameters. This leads us to ponder: how might intelligence emerge from our own brains? Within the human brain, there are nearly 100 billion neurons, which can be categorized into thousands of distinct types. Each type of neuron has its own unique and elegant structure, along with an abundance of ion channels. Cutting-edge experimental advancements suggest that due to their complex dendritic structures and ion channels, individual neurons possess extraordinary computational power, rivaling that of five-layer deep learning networks. Consequently, individual biological neurons should not be viewed as mere "point models," but rather as highly complex neural networks. Hence, our brain may contain a hyper-large neural network with parameters 4-5 orders of magnitude greater than those of ChatGPT. This emerging understanding of the computational nature of biological neurons is gradually revolutionizing traditional research based on point models in neural dynamics. AI pioneers, such as Hinton, posit that this paradigm shift will impact the algorithms and architectures of the next generation of AI. Biophysically detailed brain simulation is a mathematical tool devised to model intricate dendritic structures, rich ion channels, and synapses. In this report, I will first offer an overview of a century's worth of research on the computational functions of neuronal dendrites, tracing the theoretical underpinnings of biophysically detailed brain simulation. Subsequently, I will delve into the latest theoretical studies in dendritic computation and its implementation in AI models, illustrating how this knowledge has shaped and continues to influence the fields of neuroscience and AI. At last, I will argue that simulating a hyper-large and realistic biological neural network of our brains may be the key to unlocking human-level intelligence.

SPEAKER'S BIOGRAPHY

Du Kai, PhD, received his Bachelor's degree in Aerospace Engineering from Beihang University in 2002. He later earned his PhD and completed a postdoctoral fellowship in Neuroscience at the Karolinska Institute in Sweden. From 2008 to 2016, he was a key member of the European Union's Human Brain Project's "Brain Simulation Platform" team in Sweden. In 2020, he joined the Institute for Artificial Intelligence at Peking University as an Assistant Professor, where he leads the team to develop large-scale brain models. Du Kai established the first detailed model of medium-spiny neurons in the field and developed a detailed model of the striatum in the basal ganglia based on this work (Du et al., PNAS, 2017). His research has been published in popular journals such as PNAS, J. Neuroscience, and PLoS Comput. Bio. His main research interests are in Biophysically detailed brain simulation, dendritic computation, and novel AI systems and theories based on biophysically detailed brain models.

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